

REMARKS

Claims 1 through 14 and 38 through 50 stand rejected with claims 15 through 37 withdrawn from consideration. Applicants have cancelled claims 5, 6, 13 through 37 and 40, amended claims 1 to 4, 7 to 12, 38, 39, 41 to 45 and 48 to 50 and added newly written claims 51 to 54. As a result claims 1 through 4, 7 through 12, 38, 39 and 41 through 54 are the only claims remaining in this application.

As noted in applicants previous amendment the Examiner is queried as to the failure to acknowledge applicants' claim for priority contained in the cover sheet of this application as filed on August 8, 2001. Acknowledgement of applicants' claim for priority is respectfully requested.

Central to all of the Examiner's rejections is the Sahara et al patent (U.S. patent 6.392,282). As will be seen Sahara does not disclose or render obvious the combination of elements set out in applicants' remaining independent claims 1, 38 and 51 through 54. As a result all of the rejections remaining with respect to the remaining claims based upon Sahara comprise unsupported rejections.

It is believed that the Examiner has misapprehended the teachings of the Sahara reference which, as noted in the Abstract, is a semiconductor device having an avalanche photodiode. Specifically, the Examiner relies upon Sahara's Figure 13B and considers areas 163a, 163b, 164a and 164b as individual epitaxial layers. However, this contention is absolutely incorrect and is contrary to the disclosure in the Figure and contrary to the interpretation provided by those having even minimal skill in the art.

While applicants' claims clearly recite that these claims positively recite a deposited epitaxial layer supported by the CMOS component, Sahara specifically discloses the regions as being CMOS-type diffusions into a layer. As a result of the diffusion process, Sahara would suffer the precise problems that the present invention overcomes. Sahara mentions diffusion or the equivalent (thermal activation of dopants) over twenty times. While Sahara does not specifically identify the regions (163a, 163b, 164a and 164b) as being diffused, they have all the visual characteristics (in Figure 13B) of diffusion regions. Additionally, diffusion is specifically mentioned for guard rings 165a and 165b which in accordance with Figure 13B are indicated as being produced in the manner of the regions. It would be highly expensive and illogical to make regions 163a, 163b, 164a and 164B by a different process from the diffusion process creating guard rings 165a and 165b.

Moreover, the discussion at column 23 lines 1 through 5 discuss that Figure 13b is a "conventional APD (avalanche photodiode) and that it comprises an epitaxial layer 161 formed on the substrate 160 and it specifies that the guard rings are diffusion layers formed thereon. The regions (163a, 163b, 164a and 164b) are formed in the epitaxial layer clearly by diffusion in the same manner as the guard rings. If the regions were formed by epitaxial growth they would be located on top of the epitaxial layer 161 and they clearly are not so located.

The fact that Sahara teaches diffusion of these layers contributes to the prior art problems which would be consistent with the Sahara device, i.e. diffusion causes area

which have variable properties across an array of photodiodes in the Sahara device there will be variation between photodiode breakdown voltages and the current-voltage curve will have two sharp a knee. Some photodiodes will be correctly biased just below breakdown some will be biased into breakdown (and thus unusable) and others will be biased so far below breakdown that they will provide inadequate current multiplication. Thus consistent operation among the various photodiodes causes precisely the problems in Sahara which are discussed in the background of the invention portion of the present application.

The additional errors in the outstanding final rejection, based upon the misunderstanding of the Sahara reference, are rampant in the Final Rejection with the Examiner supposing, without any support, that the structures in the Sahara reference are somehow the structures recited in applicants' claims and that they somehow operate, not in the manner disclosed in Sahara, but in the manner disclosed in applicants' specification.

Exemplary of those errors are the Examiner's conclusion that "Sahara et al discloses on Figure 13B a photo-detector circuit." As noted above this is clearly incorrect as Sahara in Figure 13B as discussed at column 23, lines 1 through 5 teaches a conventional avalanche photo-detector (not a photo-detector circuit) in which the substrate/epitaxial layer combination of elements 160 and 161 acts as a CMOS substrate for subsequent processing by diffusion of dopant material into it.

Any person having ordinary skill in the art looking at Figure 13B will note that areas 163a, 163b, 164a and 164b are diffusion doped areas just like the guard rings 165a and 165b. The Examiner's conclusion that the circuit has a CMOS component "supporting at least one deposited epitaxial layer 164" is another example of an incorrect assumption as any person having ordinary skill in the art would know that layers 163 and 164 are diffusion layers rather than epitaxial layers (if they were epitaxial layers how would one obtain the smoothly rounded edges to the troughs in the epi layer 161 in which the layers 163 and 164 are formed - would these somehow be machined and then filled by epitaxial growth?).

For areas 163 and 164 to be epitaxially grown would be extremely expensive, time consuming and unnecessary. It is well known that conventional APDs are grown in such manner (and in fact applicants discuss applicants invention overcomes the problems associated with such conventional APDs as discussed in the background of the invention portion of this application) and Sahara identifies the structure of Figure 13B as a conventional APD.

Without going into the excruciating detail of all the additional errors in the Official Action, it is clear that the Sahara reference has nothing to do with the presently claimed invention and therefore all rejections based upon the Sahara reference are clearly unsupported. However, applicants have amended the pending claims in order to emphasize the deposited epitaxial layer which provides one of the recited active regions and it is this epitaxial layer which has the "gradual knee in a current-voltage

characteristic." The consequence of this structure is that in an array of pixel circuits each circuit has its own photodiode operating at a voltage below but near breakdown voltage in order to get current multiplication (amplification).

As noted in applicants' specification, page 27, lines 3-24 this arrangement of elements is difficult, if not impossible, with conventional CMOS photodiodes because such photodiodes have a "sharp knee" in their current-voltage curve. Secondly, CMOS photodiodes are too difficult to make with sufficiently high tolerance to insure that all photodiodes in the array have the same breakdown voltage for the required accuracy.

Applicants use CMOS technology because it is convenient to develop the pixel circuit elements and applicant uses an epitaxial layer to give a single active layer of the photodiode. In this way there is less scatter between photodiode breakdown voltages and any scatter that does exist matters less because one can bias the photodiodes in the array further from the curve knee avoiding the breakdown voltage at or above the knee where the rate of change of current with voltage is too high. As a consequence of applicants' claimed invention "a deposited epitaxial layer supported by said CMOS component where the photo-detector in response to the one active region has "a gradual knee in a current-voltage characteristic" such that the various pixels can operate close to but below the breakdown voltage in order to provide desirable current amplification and insuring that each pixel operates in a similar manner.

Independent claims 1, 38 and newly written independent claim 51- through 54 recite the features of the deposited epitaxial layer which comprises only one of the active

regions of the photodiode such that the photodiode detector in response to the only one active region has a gradual knee in a current-voltage characteristic. This operational interrelationship of claimed elements provides a clearly beneficial result over and above that disclosed in the conventional avalanche photodiode disclosed in the Sahara reference.

As a result of the above discussion, it is clear that the independent claims are patentable over the Sahara reference regardless of other references combined therewith. Accordingly, reconsideration of the rejection of applicants' claims in view of Sahara is respectfully requested.

Entry of the Amendment under Rule 116

Entry of the above amendment pursuant to the provisions of Rule 11 is respectfully requested in that applicant has cancelled the non-elected claims thereby dramatically reducing the number of claims pending in this application while adding only four new independent claims. It is noted that independent claims 15, 22, 30 and 35 were all cancelled so the total number of independent claims has not increased and the total number of claims has substantially decreased.

The above amendments if entered, clarify the distinctions between the independent claims and the Sahara and other cited references. No references disclose the elements combined in the manner of applicants' independent claims. As a result these claims are clearly patentable over the prior art.

MARSHALL et al.
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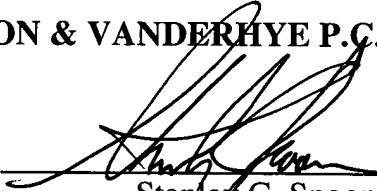
Entry of the above amendment will eliminate the need for an appeal occupying the Examiner's, applicants' and Board of Appeals' time with an application that is clearly patentable over the cited prior art. Entry of this amendment is believed to place the application in condition for allowance thereby obviating the need for an appeal. Accordingly, pursuant to 37 C.F.R. 1.116, entry of the above amendment is respectfully requested.

Having responded to all objections and rejections set forth in the outstanding Official Action, it is submitted that the pending claims are in condition for allowance and notice to that effect is respectfully solicited. In the event the Examiner is of the opinion that a brief telephone or personal interview will facilitate allowance of one or more of the above claims, he is respectfully requested to contact applicants' undersigned representative.

Respectfully submitted,

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